INFLUENCE OF TEAK PLANTATIONS ON DIFFERENT

SOIL CHEMICAL PROPERTIES IN SOUTHERN INDIA

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ABSTRACT

A study was undertaken to evaluate various chemical properties of soils under teak plantations as influenced by different agro climatic zones and age gradations in Karnataka viz., Northern Transition Zone (NTZ), Northern Dry Zone (NDZ) and Hilly Zone (HZ). Soil properties such as pH (6.59), electrical conductivity (0.59), organic carbon (1.40), available nitrogen (270.72 kg/ha), available phosphorous (38.78 kg/ha) and available potassium (302.22 kg/ha) at 20 years were significantly improved when compared to soils under 10 year old plantation i.e. pH (7.24), electrical conductivity (0.71), organic carbon (0.90), available nitrogen (250.78 kg/ha), available phosphorous (23.22 kg/ha) and available potassium (276.89 kg/ha). It can be concluded that higher productivity and increasing age of teak plantations may have significantly improved soil chemical properties of the soils under teak plantations.

KEYWORDS: Teak, Chemical Properties, Agro - Climatic Zones and Age - Gradations

Original Article

INTRODUCTION

Recent large-scale afforestation on farmlands represents a major land-use change in developing countries in general and India in particular. The area under teak (Family: Lamiaceae) plantations has been steadily increasing, teak posses rank third among hardwood species of tropics in terms of area under plantations established globally. *Tectona grandis* covers 2.250 m ha, with 94 % in tropical Asia, majority of teak area being covered by India and Indonesia, while 4.5 per cent of teak plantations are in tropical Africa and the rest are in tropical American region (Krishnapillay 2000; Katwal 2003). This change in land-use can be attributed to a combination of declining returns from farming alone and the expectation of increased future returns from forestry (Chirino 2010). In addition to the possible economic benefits associated with the establishment of teak plantations, establishment of forest plantations in non-agricultural agricultural lands may help to ameliorate microclimate and also restore degraded lands and control soil erosion (Chirino 2010). In spite of having little scientific evidence, generally believed that plantation monocultures decrease soil health in different ways. However, globally many scientific findings signifies beneficial effects associated with plantation forests such as an increase in available forms of phosphorus, nitrogen, potassium and betterment in soil conditions such as pH, electrical conductivity & improved organic matter. (Ziblim et al. 2012; Dinakaran and Krishnayya 2010). Most studies regarding the influence of teak plantations on soil properties are either restricted to a particular agro ecological situation or particular age of the plantations. Hence it was felt that a closer examination of changes in soil properties over time following in different agro ecological situations is necessary to understand the mechanisms responsible for changes in the soil chemical properties, which in turn will assist in the developing effective long term management practices for maintenance of soil health.

The specific objective of this study was to quantify the effects of the teak plantations on different soil chemical properties in different agro-ecological situations of southern India.

MATERIAL AND METHODS

The present study was conducted in three different agro climatic zones of Karnataka *i.e.* NDZ (14^0 39' to 17^0 24' N latitude and 74^0 34' to $77^0$04' E longitudes), NTZ (14^0 13' to 16^0 41' N latitude and 74^0 13' to 75^0 38' E longitude) and HZ (11^0 56' to 15^0 46' N latitude and 74^0 31' to 76^0 and 76^0 45' E longitude.). In each of the climatic zones, teak plantations of three age gradations *viz*. 10, 15 and 20-year were chosen for the study. The soils in NDZ and HZ were quite similar. The major soil types in these two zones consist of medium black to deep black soils and shallow black soils, whereas, in HZ, red sandy loam, lateritic and medium black soils are predominant. Three Agro climatic zones were considered as main plots and three age gradations in each of the agro climatic zones were taken as sub plots. Thus there were three main plot and 3 sub plot treatments and three replications were maintained. Due care was taken to choose sub plots under similar agro climatic situations of respective main plots. Since it is difficult to get established teak plantations of exact age gradation in similar agro climatic situations of each zone, a range of 1-2 years in each age gradation was considered.

In each sample plot (10 x 10 m), three soil samples were collected using simple randomization technique. Soil samples were collected from 0- 60 cm layers of soil pits and air-dried, passed through 2 mm sieve and analyses was carried out by using standard procedures: soil pH- Digital pH meter (Jackson 1967), EC (dSm^{-1}) - Conductivity meter method (Jackson 1967), Organic carbon content- Walkely-Black wet oxidation method (Jackson 1967), Available nitrogen (kg/ha)- Blacks method (Jackson 1967), Available phosphorus (kg/ha)- Brays's method (Tandon 1995). Fisher's method of analysis of variance and interpretation of data was applied as given by Snedecor and Cochran (1967). The level of significance used was p = 0.05. The mean values of main plots, sub plots were subjected to M-STAT- C programme on a computer.

RESULTS AND DISCUSSIONS

It was observed that soil chemical properties such as pH, electrical conductivity, organic carbon, available nitrogen, available phosphorous and available potassium improved with age of the teak plantations. (Table 1 & 2). Soil pH differed significantly due to agro climatic zones and age gradations of teak plantations (Table 1). Soil pH was significantly improved in NTZ (7.00) than in NDZ (8.60) and HZ (5.20). Soil pH was significantly better in 20 year plantations (6.59) than in 15 year (6.94) and 10 year plantations (7.24). In NDZ and 9, there was significant reduction in soil pH with increase in age gradation from 10 to 20 years. Whereas, in NTZ reduction in soil pH was observed in age from 10 (7.30) to 15 (6.89) years only further increase in age gradation from 15 (6.89) to 20 (6.72) years had no significant effect on soil pH. Similar trend was observed in electrical conductivity (Table 1) which, it was significantly higher in NDZ (0.81 dSm^{-1}) than in NTZ (0.60 dSm^{-1}), which in turn was on par with HZ (0.55 dSm^{-1}). Electrical conductivity varied significantly in 10 year plantations (0.71 dSm^{-1}) than in 15 year (0.66 dSm^{-1}) and 20 year plantations (0.59 dSm^{-1}). Electrical conductivity in 10 year plantation of NTZ (0.67 dSm^{-1}) was significantly higher than HZ plantations (0.60 dSm^{-1}). Electrical conductivity in case of 15 and 20 year plantations in NTZ (0.59 and 0.53 dSm^{-1}) was on par with HZ (0.56 and 0.50 dSm^{-1}).

Organic carbon content was significantly higher in NTZ (1.30 %) than in NDZ (0.97 %) and HZ (1.20 %). It was higher in NTZ to an extent of 34.0 and 8.3 per cent over NDZ and HZ respectively. Organic carbon content was

significantly higher in 20 year plantations (1.40 %) than in 15 year (1.17 %) and 10 year plantations (0.90 %). The extent of increase of organic carbon in 20 year plantation was 19.6 and 55.5 per cent over 15 year and 20 year plantation respectively. In case of 10 year plantations, organic carbon in HZ (1.00 %) was significantly higher than NTZ (0.91 %). Whereas, in case of 15 and 20 year plantation, organic carbon in NTZ (1.36 and 1.65 %) was significantly higher than HZ (1.22 and 1.39 %). While organic carbon was significantly lower in all the three age gradations in NDZ (Table 1).

Available nitrogen was significantly higher in NTZ (279.67 kg/ha) than in HZ (230.98 kg/ha) and was on par with NDZ (270.22 kg/ha). Available nitrogen was significantly higher in 20 year plantations (270.72 kg/ha) than in 15 year (259.38 kg/ha) and 10 year plantations (250.78 kg/ha). Available N in ten year plantation of NTZ (269.33 kg/ha) was on par with fifteen year plantation in NDZ (269.67 kg/ha). Similar trend was observed in case of 15 and 20 year plantations in NTZ. While significantly lower available nitrogen was recorded in HZ at all the three age gradations (Table 2).

Available phosphorus differed significantly due to agro climatic zones and age gradations of teak plantations (Table 2). Available phosphorus was significantly higher in HZ (37.78 kg/ha) than in NDZ (25.00 kg/ha) while it was on par with NTZ (32.22 kg/ha). Available phosphorus was higher in HZ to an extent of 17.2 and 51.1 per cent over NTZ and NDZ respectively. Available phosphorus was significantly higher in 20 year plantations (38.78 kg/ha) than in 15 year (33.000 kg/ha) and 10 year plantations (23.22 kg/ha). There was no significant difference in available phosphorus content in case of 10 and 15 year plantation in NDZ and 8, available phosphorus in NDZ (18.67 kg/ha and 28.67 kg/ha) was on par with NTZ (20.67 kg/ha and 32.33 kg/ha). While in 20 year plantations available phosphorus was significantly higher in NTZ (43.67 kg/ha) than in NDZ (25.00 kg/ha). Table 2 reveals that available potassium was significantly higher in NTZ (366.22 kg/ha) than in HZ (140.78 kg/ha), while it was on par with HZ (140.78 kg/ha). Available potassium was significantly higher in 20 year plantations (302.22 kg/ha) than in 15 year (288.00 kg/ha) and 10 year plantations (276.89 kg/ha). In case of 10 and 15 year plantations, available potassium in NDZ (353.00 kg/ha and 357.00 kg/ha) was on par with NTZ (353.33 kg/ha and 364.00 kg/ha). While in case of 20 year plantations available nitrogen in 8 (381.33 kg/ha) was significantly higher than NDZ (370.33 kg/ha). While HZ exhibited significantly lower available potassium at all the three age gradation.

Irrespective of agro climatic situations, soil chemical properties improved significantly ($p < 0.05$) in 20 years old teak plantations when compared to 10 years old teak plantations. This could be attributed to the relatively high amount of organic materials that might have resulted from litter fall from the trees in the plantations. Jones et al. (1996) stated that the amount of plant biomass incorporated into the soil improvises soil health and nutrient status. Similar findings were also reported by Dinakaran and Krishnayya (2010) for, soil organic matter in afforested areas under Teak, Bamboo and mixed vegetation with increases being greatest under Teak plantations, while Sharma et al. (2011) reported that teak under agroforestry system improved the soil quality by increasing organic carbon, soil porosity as well as available N, P and K. Teak was also recommended for agro forestry practices particularly, where the soil needs some level of improvement in nitrogen and phosphorus respectively.

CONCLUSIONS

Soil chemical properties like pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium were found to be superior in NTZ compared to other zones. On the other hand it was found that various soil chemical properties have significantly improved along increment in age of the plantations.

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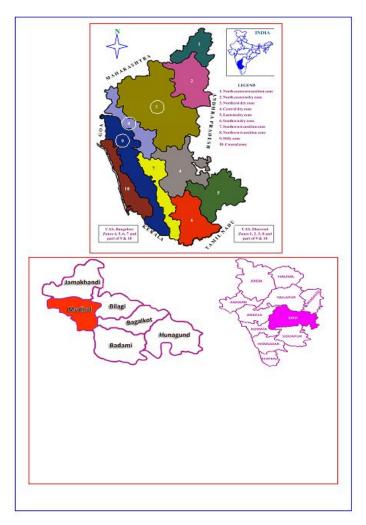
APPENDICES

Figure 1: Maps Showing the Agro Climatic Zones Selected for the Study in Karnataka

Table 1: pH, Electrical Conductivity (dSm^{-1}) and Organic Carbon (%) of Soils as Influenced by Teak in different Agro Climactic Zones and Age Gradations

Main plot (M)/Sub plot (S)	pH				Electrical conductivity (dSm^{-1})				Organic carbon (%)			
	M_1 - NDZ	M_2 - NTZ	M_3 - HZ	Mean	M_1 - NDZ	M_2 - NTZ	M_3 - HZ	Mean	M_1 - NDZ	M_2 - NTZ	M_3 - HZ	Mean
S_1 - 10 year	9.10	7.30	5.33	**7.24**	0.87	0.67	0.60	**0.71**	0.80	0.91	1.00	**0.90**
S_2 - 15 year	8.75	6.89	5.17	**6.94**	0.83	0.59	0.56	**0.66**	0.94	1.36	1.22	**1.17**
S_3 - 20 year	7.93	6.72	5.11	**6.59**	0.74	0.53	0.50	**0.59**	1.16	1.65	1.39	**1.40**
Mean	**8.60**	**7.00**	**5.20**		**0.81**	**0.60**	**0.55**		**0.97**	**1.30**	**1.20**	
For comparing the means of:	SEm ±		CD 5%		SEm ±		CD 5%		SEm ±		CD 5%	
Main plot (M)	0.06		0.23		0.02		0.09		0.005		0.019	
Sub plot (S)	0.08		0.25		0.02		0.06		0.023		0.071	
Interaction (M x S)	0.11		0.25		0.03		0.06		0.033		0.071	

NDZ   NTZ   HZ

**Table 2: Available Nitrogen, Phosphorus and Potassium (kg/ha) of Soils as
Influenced by Teak in different Agro Climatic Zones and Age Gradations**

Main plot (M)/Sub plot (S)	Available nitrogen (kg/ha)				Available phosphorous (kg/ha)				Available potassium (kg/ha)			
	M₁ - NDZ	M₂ - NTZ	M₃ - HZ	Mean	M₁ - NDZ	M₂ - NTZ	M₃ - HZ	Mean	M₁ - NDZ	M₂ - NTZ	M₃ - HZ	Mean
S₁ - 10 year	259.67	269.33	223.33	**250.78**	18.67	20.67	30.33	**23.22**	353.00	353.33	124.33	**276.89**
S₂ - 15 year	269.67	278.33	230.13	**259.38**	28.67	32.33	38.00	**33.00**	357.00	364.00	143.00	**288.00**
S₃ - 20 year	281.33	291.33	239.48	**270.72**	27.67	43.67	45.00	**38.78**	370.33	381.33	155.00	**302.22**
Mean	**270.22**	**279.67**	**230.98**		**25.00**	**32.22**	**37.78**		**360.11**	**366.22**	**140.78**	
For comparing the means of:	SEm ±		CD 5%		SEm ±		CD 5%		SEm ±		CD 5%	
Main plot (M)	7.52		29.43		2.58		10.10		2.76		10.81	
Sub plot (S)	1.20		3.69		1.87		5.76		3.53		10.83	
Interaction (M x S)	1.70		3.70		2.65		5.78		4.99		10.87	

NDZ   NTZ   HZ